UNITED STATES DEPARTMENT OF AGRICULTURE

Bureau of Agricultural Chemistry and Engineering

Division of Agricultural Chemical Research

EMBEDDING SPECIMENS IN METHACRYLATE RESINS:

A Selected List of References with Annotations

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For the convenience of those desiring detailed information on the use of methacrylate resins for embedding specimens of biological or other materials for preservation and examination, the following references have been selected as being of practical value. Annotations have been included to facilitate finding the particular information sought.

These references are divided into three sections: (A) Those relating to processing data and to physical and chemical characteristics of methacrylate resins; (B) those describing specimen-embedding technique; and (C) those dealing with proposed use of these resins in microscopic preparations.

Acknowledgments are made to E. I. du Pont de Nemours & Company, Inc., and to Röhm & Haas Company, Inc., for assistance in compiling the list here presented.

(A) Processing Data, and Physical and Chemical Characteristics of of Methacrylate Resins

(1) Neher, H. T.

1936. Acrylic resins. Indus. and Engin. Chem., vol. 28, pp. 267-271. History of development; methods of production; data on polymerization; properties and uses. Early references and patent listings not included in this bibliography.

(2) Frederick, D. S.

1936. Acrylic resins. Mod. Plastics, vol. 14, pp.32 and 108 (Oct.). Outline of development; optical and mechanical characteristics of polymers.

(3) Dittmar, H. R.

1936. Methacrylate resins. Mod. Plastics, vol. 14, pp. 40-43 and 58-62 (Nov.).
Properties and synthesis of monomeric methacrylates; polymerization; catalysts and inhibitors; properties of polymers; applications and uses, including impregnation with monomer and polymerization in situ. References and patent listings not included in this bibliography.

(4) E. I. du Pont de Nemours & Co.
1936. Methacrylate resin. Indus and Engin. Chem., vol. 28, pp.1160-1163.
Properties and synthesis of monomeric methacrylates; polymerization and properties of polymers; applications and uses. References and patent listings not included in this bibliography.

(5) Kline, G. M., and B. M. Axilrod.
1936. Methods of testing plastics. Indus. and Engin. Chem., vol. 28, pp. 1170-1173.
Testing methods for clarity, scratch resistance, and indentation hardness.

(6) Axilrod, B. M., and G. M. Kline.
1937. Study of transparent plastics for use in aircraft. Research Paper R. P. 1031, Jour. Res. Nat'l Bur. Standards, vol. 19, pp. 367-400.
Study of plastics, covering optical properties; resistance to weathering; accelerated aging; scratch resistance; indentation hardness; impact strength; shrinkage; resistance to water, alkalis and kerosene; bursting strength; flammability.

(7) Frederick, D. S.
1937. Acrylic resins. Mod. Plastics, vol. 15, pp. 11-13 (Oct.).
Properties of acrylates and metharcylates, including softening points, toughness, and pliability of esters from methyl up to amyl in both series.

(8) Randolph, A. F.
1937. Methyl methacrylate resin. Mod. Plastics, vol. 15, pp. 28-29 and 60 (Oct.).
Properties; effect upon dyestuffs; molding characteristics; information on machining and polishing.

(9) Breskin and Charlton Publishing Crop.
1937. Plastics properties chart. Mod. Plastics, vol. 15, insert betw. pp. 120-121 (Oct.)
Charted characteristics of principal types of plastics commercially available at date of issue.

(10) Kline, G. M.
1938. Permanence of plastics. Amer. Soc. for Testing Materials, Symposium on plastics, pp. 35-51.
Resistance of plastics to effects of light (including ultraviolet), heat, water, and chemical reagents.

(11) Strain, D. E.
1938. Polymerization of methyl methacrylate in organic solvents. Indus. and Engin. Chem. vol. 30, pp. 345-347.
Effect of temperature and catalyst upon molecule size. Influence of solvents on molecular weight of polymer.

(12) Reinhart, F. W., and G. M. Kline.
1939. Film-forming plastics. Indus. and Engin. Chem. vol. 31, p. 1522.
Effect of solvents, diluents and plasticizers upon methacrylate resins, cellulosic plastics, and chlorinated rubber.

(13) Strain, D. E., R. G. Kennelly, and H. R. Dittmar.
1939. Methacrylate resins. Indus. and Engin. Chem. vol. 31, pp. 382-387.
Physical properties of polymers; solubility; elasticizers; compatibility of methacrylate resins with one another; compatability with other resinous materials; methacrylate resin hot-melt blends. References and patent listings not included in this bibliography.

(14) Kline, G. M., W. A. Crouse, and B. M. Axilrod.
1940. Accelerated weathering of transparent plastics. Mod. Plastics, vol. 18, pp. 49-57 and 86 (Aug.).
Tests made to evaluate effectiveness of several types of accelerated aging apparatus in comparison with outdoor exposure in causing crazing, fusing, blooming, discoloration, and warping in synthetic resins and cellulosic plastics.

(15) Kline, G. M., A. R. Martin, and W. A. Crouse.
1940. Sorption of water by plastics. Mod. Plastics, vol. 18, pp. 119-123, 152-154 (Oct.).
Report on tests to determine sorption of water by phenol-formaldehyde, urea-formaldehyde, vinyl chloride, vinyl chloride-acetate, vinyl butyral, methyl methacrylate, styrene, cellulose nitrate, cellulose acetate, ethyl cellulose, bituminous resins and casein.

(16) E. I. du Pont de Nemours & Co., Plastics Dept.
(1941) Directions for handling "Lucite" methyl methacrylate cast resin sheeting. (DUPONT Information Sheet)
Protective paper coating; polishing; cutting; drilling; shaping; cleaning; mounting and fitting; cementing.

(17) E. I. du Pont de Nemours & Co., Ammonia Dept.
1941. Methacrylate resin hot-melt blends. (DUPONT Information Sheets)
Blends with other resins, waxes, and plasticizers resulting in compositions which become fluid at temperatures below 200° C.

(18) E. I. du Pont de Nemours & Co., Ammonia Dept.
1941. Polymerization of methyl methacrylate monomer. (DUPONT Information Sheets).
Directions for removal of inhibitor; catalysts for polymerization; preliminary partial polymerization; procedure for casting in molds; after-heating, machining and polishing; precautions because of flammability and toxicity of monomer vapors.

(19) Röhm & Haas Co., Inc.
(1941). "Plexiglas" acrylic plastic. (Röhm & Haas Information Booklet)
Acrylic plastics; properties of "Plexiglas", optical, chemical, electrical and physical; applications; molding powders; table of properties.

(20) Röhm & Haas Co.
1941. Synthesis flow-sheet. (Röhm & Haas Information Sheet)
Outline of synthesis from petroleum, water, air and alcohol.

(21) Röhm & Haas Co., Inc.
(1941). Technical data (on) "Plexiglas", (1) optical properties. (Röhm & Haas Information Booklet)
Index of refraction (1.49); dispersion (0.008); visible light transmission (92%); optical density (0.036); ultra-violet light transmission; X-ray transmission; light scattering tendency (2%); surface irregularities; optical homogeneity; permanence; applications; white translucent "Plexiglas".

(22) Röhm & Haas Co., Inc.
1941. "Plexiglas" - directions for handling, cleaning, polishing. (Röhm & Haas Information Booklet)
Masking and installation; fabrication; forming; cleaning; polishing, hand buffing and machine buffing.

(23) Röhm & Haas Co. Inc.
1941. "Plexiglas" fabricating manual. (Röhm & Haas Information Booklet)
Storing; unmasking; scribing; machining; forming; checking fixtures; cementing; cleaning; finishing; repairing and patching.

(B) Specimen Embedding Technique Employing Methacrylate Resins

(24) Hibben, J. H.
1937. The preservation of biological specimens by means of transparent plastics. Science, vol. 86, pp. 247-248.
Describes advantages of preservation of biological specimens in transparent plastic, typified by polymerized methyl methacrylate; procedure outlined for preliminary partial polymerization of resin, preparation of specimens, use of catalysts, selection of molds for casting, and final polymerization; subsequent sectioning and resurfacing.

(25) Knight, H. G.
1937. The preservation of biological specimens by means of transparent plastics. Science, vol. 86, pp. 333-334.
Outline of agricultural specimens preservation studies in Bureau of Chemistry and Soils (now Bureau of Agricultural Chemistry and Engineering), U. S. Department of Agriculture. Process for preservation (by chemical means) of natural colors in fresh plant materials (which are ordinarily impermanent) is being developed by G.R. Fessenden. Second phase of project dealing with embedding specimens in methyl methacrylate was begun by F. L. Goll, Bureau of Plant Industry, and modified and improved by C. E. Sando. Representative specimens such as seeds and insects have been embedded, but many difficulties remain to be overcome. Only relatively dry materials can be successfully mounted in methyl methacrylate; attempts to embed fresh flowers and leaves resulted in color loss; irridescent butterflies do not lend themselves to embedding, but mounts have been made by process which prevents actual contact between resin and specimen.

(26) Cole, E. C.
1938. Methyl methacrylate as a laboratory tool. Science, vol. 87, pp. 396-398.
Refers to use of methyl methacrylate rods for carrying light to inaccessible places. Reports using this resin in dioxane solution as a microscopic mounting medium in place of Canada balsam or gum dammar. Museum jars prepared by using plastic tubing with bottoms and covers cemented on with monomeric methyl methacrylate. Suggests chloroform solution of polymerized methyl methacrylate for embedding specimens, but reports excess shrinkage and bubble formation.

(27) Anonymous.
1938. Scientific third award. Mod. Plastics, vol. 16, p. 36 (Nov.)
Agricultural and biological specimens embedded in methyl methacrylate, designed, machined and polished by C. E. Sando (Bureau of Agricultural Chemistry and Engineering), U. S. Department of Agriculture.

(28) Anonymous.
1938. Botany and Biology. Mod. Plastics, vol. 16, pp. 36-37 (Dec.)
Application of methyl methacrylate by C. E. Sando, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture, to embedding biological and botanical specimens. Procedure outlined: Dehydration of specimens, preliminary partial polymerization with catalyst and heat, casting in mold, removal of air bubbles by evacuating, completion of polymerization with controlled heating, removal from mold and special treatment to prevent subsequent crazing, machining and polishing. Extreme care necessary with each step; several difficulties still to be overcome. Illustrations.

(29) Anonymous.
1939. Two methods of preserving plant and insect specimens in natural colors developed by government scientists. Agricultural News Letter (du Pont) vol. 7, p. 67 (June-July).
Two methods of preserving agricultural specimens developed in U. S. Department of Agriculture. Processes supplement each other, for dried or for fresh material. In method studied by C.E. Sando specimens are embedded in methacrylate after drying or dehydration in alcohol or ether, applicable to corn and other grains or seeds, insects and other specimens that do not lose color or shape on drying. Other method developed by G. R. Fessenden is a chemical process for toughening tissues and setting natural color of fresh plant material; preserved specimens sealed between sheets of transparent film. Difficulties still to be overcome in both methods.

(30) Anonymous.
1940. Preserving specimens. Amer. Nurseryman, vol. 71, pp.30-31.
Two processes developed in U. S. Department of Agriculture, one by C. E. Sando for embedding dried material in methacrylate, other by G. R. Fessenden for chemically preserving natural color of fresh plant material.

(31) Yelland, W. E.
1939. Warp size distribution on yarn (using method of study employing methacrylate embedding). Textile Manufacturer, vol. 65, p. 300.
Embedding medium prepared by using methyl methacrylate and plasticizer. After catalyzed polymerization in gelatin coated glass mold, embedding yarn can be sectioned for study.

(32) Anonymous.
1939. Preserved in plastics. Sci. Amer., vol. 161, p. 217.
Outline of two methods for preservation of agricultural specimens. (1) For seeds, insects and other material that can be dehydrated without loss of color or shape, embedding in methacrylate resin is being studied by C. E. Sando; (2) for preserving natural color of fresh plant material by chemical treatment with subsequent sealing between sheets of transparent film, a process is being developed by G. R. Fessenden.

(33) Bell, J. F.
1939. Notes on uses of methyl methacrylate "lucite" in a geological laboratory. Econ. Geol., pp. 804-811 (Nov.).
Detailed directions for embedding mineralogical specimens in methyl methacrylate; removal of inhibitor, suitable percentages of benzoyl peroxide catalyst, prepolymerization, casting in glass molds, completion of polymerization at controlled temperature in water bath to reduce bubble formation, machining and polishing. Caution necessary because of toxicity and flammability of monomer vapor.

(34) Puckett, W. O.
1940. Ethyl methacrylate as a mounting medium for embryological specimens. Science, vol. 91, pp. 625-626.
Detailed directions for removal of inhibitor, addition of catalyst, preliminary partial polymerization, selection of molds, preparation of specimens (as for balsam mounting), dehydration and transfer to prepolymerized resin base in mold, addition of balance of partially polymerized resin, completion of polymerization, and removal from mold by chilling. Preparation of microscope slide mounts described, using rings cut from methacrylate rod and specimens mounted with partially polymerized resin.

(35) Shrock, R. R.
1940. "Lucite" as an aid in studying hard parts of living and fossil plants. Jour. Paleontology vol. 14, pp. 86-88.
Detailed description of use of methyl methacrylate in making molds, casts, replicas, and impressions, and as a mounting medium for sections.

(36) Röhm & Haas Co.
1941(?). Embedding specimens in "Plexiglas". (Röhm & Haas Information Sheet)
Dehydration of specimens; inhibitor removal; catalysts; preliminary partial polymerization; procedure for embedding specimens; allowance for 20% shrinkage of resin during polymerization; machining and polishing; credit to C. E. Sando, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture, for working out above procedure.

(37) Randall, A., and A. W. C. Menzies.
1941. Histological sectioning of hard tissues by a new technique. Science, vol. 93, pp. 189-190.
Describes method of embedding tissue in methyl methacrylate and then grinding to thin sections. Polymerizes resin without removing inhibitor.

(38) Wheatley, M. D.
1941. Preservation of biological specimens with isobutyl methacrylate polymer. Science, vol. 94. pp. 49-50.
Coats insects and other dry specimens with isobutyl methacrylate applied by successive dippings into toluene solution of resin, made up of 10 parts solids in 100 parts solvent. Describes special preparation of various specimens prior to coating.

(C) Methacrylate Resins in Microscopic Preparations

(39) Skiles, B. F., and C. E. Georgi.
1937. The use of synthetic resins in the preparation of permanent bacterial mounts. Science, vol. 85, pp. 367-368.
Describes use of "Pontalite" ("Lucite") and "Vinylite" resins in place of Canada balsam, with or without cover-glass.

(40) Richards, O. W., and J. A. Smith.
1938. "Lucite" not a substitute for Canada balsam when mounting microscopic slides. Science, vol. 87, p. 374.
Reports difficulties with contraction and bubble formation, and also with fading of stains.

(41) O'Brien, H. C., and R. T. Hance.
1940. A plastic cover glass, isobutyl methacrylate, Science, vol. 91, p. 412.
Reports use of "Clarite" ("Nevillite") and of isobutyl methacrylate for mounting medium in place of Canada balsam or gum dammar; also describes method for using methacrylate without cover-glass for deep mounts.

(42) Suntzeff, V., and I Smith.
1940. The use of plastic as a substitute for cover glasses. Science, vol. 92, pp. 17-18.
Proposes cellulose acetate film as substitute for cover-glass, cemented with isobutyl methacrylate. Reports difficulty with curling of edges which is helped by slow drying.

(43) Hamilton, J. H.
1940. Isobutyl methacrylate as a mounting medium for histological specimens. Science, vol. 92, p. 44.
Reports isobutyl methacrylate not satisfactory with certain histological techniques as a substitute for Canada balsam as proposed by O'Brien and Hance (Science, [illegible]0).

[illegible] methacrylate polymer as a
[illegible] 92, p. 268.
[illegible]late is unsatisfactory,
because (1) it does not
2) certain stains are
at relatively low tem-
e index is not suitable

(45) Suntzeff, V., and I. Smith.
1941. The use of plastic as a substitute for cover glasses. Science, vol. 93, pp. 157-158.
Refers to note by same authors (Science, vol. 92, pp. 17-18, 1940) stating that cellulose acetate cover slips cemented with isobutyl methacrylate gave good service for short periods, but the sections became more or less decolorized in a few months; usefulness of this method restricted to temporary mounts.

(46) Dunham, W. B.
1941. Permanent mounts of virus infected chorioallantoic membranes. Science, vol. 94, p. 120.
Describes dehydration through alcohol and xylene and coating of specimen with isobutyl methacrylate polymer in xylene solution (33-1/3% solids), applying second coating after first hardens.

Note: See references (26), (31), (34), (35), and (37) for additional data on microscopic preparation technique.

In giving the names of companies in connection with this list of references it should be understood that their products are not recommended in preference to similar products of companies not mentioned.